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Macroeconomic Volatility under Alternative Exchange Rate Regimes in Turkey

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Abstract

After the collapse of fixed exchange rate regime in 1980, alternative regimes were adopted in Turkey. The "crawling peg" regime (1980-81) is followed by "managed float" (1981-99), "crawling peg" (1999-2001) and "free floating" (2001-) in "de jure" classification. This paper examines the behavior of the macroeconomic variables in terms of volatility across exchange rate regimes in "de jure " and "de facto" classifications, using monthly data over the period 1980-2006. We find a strong GARCH effect for the real exchange rate, inflation and foreign exchange reserves. The findings of the t-test indicate that the variations in the mean of most of the macroeconomic variables are not statistically different from each other under "de facto" regimes The results of this study suggest the existence of "de facto" regime neutrality.

JEL Classification: C22, E42, E44, F31.
Keywords: Exchange rate regimes, macroeconomic variables, exchange rate volatility, conditional heteroscedasticity models.

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1. Introduction

The recent major emerging market financial crises posed serious challenges for policy makers in the setting of exchange rate regimes.[1] The "bipolar" view of exchange rates, indicating that intermediate regimes are not sustainable (Fisher, 2001) and crisis-prone (see Summers, 2000; Edwards, 2001; Bubula and Otker-Robe, 2003; Husain et al., 2005), is supported in all of these financial crisis.[2] This idea is primarily associated with the impossible trinity since pegs cannot be maintained under high capital mobility and independent monetary policy. Therefore, flexible exchange regimes must be implemented. Proponents of pegged regimes, however, argue that this system promotes financial stability and reduces the likelihood of banking crises (Domaç and Peria 2000). Both fixed and flexible exchange rate regimes, on the other hand may also trigger financial fragility (Grauwe and Grimaldi 2002). Hence, there is no real consensus about the choice of exchange rate regimes. As Frankel (1999) states that "no single currency regime is best for all countries and that even for a given country it may be that no single currency regime is best for all time."

It is believed that the choice of exchange rate regime might have contributed to macroeconomic instability and conversely, a shift in exchange rate regime might have improved macroeconomic performance. The behavior of the macroeconomic variables across exchange rate regimes appears to be a significant puzzle in international macroeconomic literature. In this context, the contributions that can be established from an empirical analysis are highly relevant. The issue of macroeconomic volatility and exchange rate regime choice is particularly important for the financially vulnerable countries that frequently switch from one regime to another. While many developing countries have moved to a flexible exchange rate regime within the last three decades, it is surprising that there are only few studies that analyze the relationship between exchange rate regimes and volatility of macroeconomic variables.

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[1] The countries faced with crises, Mexico (1994), Asia (1997), Russia (1998), Brazil (1999), Argentina (2001) and Turkey (2001), adopted currency/basket pegs or tightly-managed exchange rate regime before crises.

[2] Intermediate regimes, or soft pegs, cover the regimes between super-fixed or hard pegs (currency union, currency board and dollarization) and floating (managed float and independently floating). These regimes consist of forward/backward looking crawling pegs/bands, horizontal bands, conventional fixed pegs and tightly-managed float (Fisher, 2001; Bubula and Otker-Robe, 2003).

The aim of this study is to add relatively small stock of evidence on the literature in the context of a developing country by investigating whether changes in time-varying volatility of a set of macroeconomic variables can be attributed to changes in exchange rate regimes in Turkey under "de jure" and "de facto" classifications.

The contribution of this paper is three-fold: First, although several studies have investigated the volatility of macroeconomic and/or financial variables for Turkey, none of them have examined the impact of exchange rate regimes on the volatility of macroeconomic variables.[3] To the authors' best knowledge, this will be the first study analyzing the relationship between the volatility of macroeconomic variables and exchange rate regimes for Turkey. Second, it would be interesting to investigate how fundamental variables differ in terms of volatility under alternative exchange rate regimes since Turkey has adopted several different exchange rate regimes in the last two decades. Considering "de jure" and "de facto" classifications implies the deviation of commitment from actual behavior. Table 1 presents "de jure" and "de facto" classifications of exchange rate regimes.[4]

Table 1
"De Jure" and "De Facto" Exchange Rate Regime Classifications: 1980-2006

De Jure Regimes		**De Facto Regimes**	
01.01.1980-30.04.1981	Crawling band	01.01.1980-31.03.1981	Crawling peg
01.05.1981-30.11.1999	Managed float	01.04.1981–28.01.1998	Managed float
01.12.1999-16.02.2001	Crawling peg	02.02.1998–31.12.1998	Crawling peg around DM
19.02.2001-	Free float	04.01.1999–31.01.2001	Crawling peg around €
		01.02.2001–	Free float

Finally, the results of this study may provide some important implications for policymakers. If macroeconomic volatilities are found to be the same under different exchange rate regimes (regime neutrality) and if the government aims at stabilizing the fundamental variables, a switch of the exchange rate regime appears

[3] Some of these studies cover the *exchange rate volatility* (Selçuk, 2004); *interest rate volatility* (Aydın and Özcan, 2005); *output volatility* (Berument and Paşaoğulları, 2003); *the relationship between exchange rate volatility and stock market volatility* (Salman and Salih, 1999; Kasman, 2006); *the relationship between volatility of exchange rate/parity and foreign trade* (Doğanlar 2002, Vergil 2002, Kasman and Kasman, 2005; Kahyaoğlu and Utkulu, 2006).

[4] "De jure" classification is based on the monetary authority's policy statement or formal commitment on the exchange rate regime policy. "De facto" approach is simply the actual or observable behavior since countries may not choose to commit or float and therefore not to announce. "De facto" classifications are taken from (Reinhart and Rogoff, 2002). They develop "exchange rate flexibility indices", $\varepsilon / P(\varepsilon < \%1)$, to determine the degree of exchange rate flexibility under free float and managed float regimes. In their study, the data ends in October 2001. We extended this period until April 2006, since there is no recent regime change in the Turkish economy.

to be ineffective.[5] If, however those volatilities are quite different across exchange rate regimes, these empirical results can serve as a guide for the effects of such a change and policymakers may take appropriate policy actions to reduce the risk of exchange rate regime shifts on macroeconomic volatility.

The remaining of the paper is organized as follows. Section 2 gives the literature review. Section 3 presents the history of exchange rate management, macroeconomic policies and structural reforms in the Turkish economy. Section 4 gives the dataset. Section 5 explains the conditional volatility models and reports the empirical results. Section 6 analyzes the relationship between the volatility of macroeconomic variables and exchange rate regimes. Section 7 concludes.

2. Literature Review

Since the work of Mundell (1961), a vast literature has developed to examine the link between exchange rate regimes and macroeconomic performance. On the theoretical front, in the stochastic IS-LM model Weber (1981), Turnovsky (1976) argue that the effect of exchange rate regimes on the macroeconomic performance depends on following two conditions: first, the types of shocks (domestic or foreign) that the domestic economy usually faces and the second, international mobility of capital that country has. If country has free mobility of capital and the exchange rate is flexible, then domestic-sourced LM type shocks will create large fluctuations in output, inflation and the exchange rate. If, however, exchange rate is fixed and capital is mobile, then LM shocks will have no effect on output or inflation. In contrast, a foreign-sourced shock will have larger affects on the domestic economy if the exchange rate is fixed.

More recently, some models, Mundell-Fleming-Dornbush model and new open economy macroeconomics initiated by Obstfeld and Rogoff (1995), examine the question of how the exchange rate regime affects the international trade. The general argument is that exchange rates (both nominal and real) will be more variable under flexible then under fixed exchange rates and this volatility will be harmful to trade.[6] These theoretical arguments do not reach a clear conclusion concerning the superiority of exchange rate regimes that will reduce the real volatility.

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[5] Monetary authorities change exchange rate policies not only for the macroeconomic stability, but also to break inflation inertia, to promote export, to realize integration in both its capital and current account transactions with another or a group of other economies and to gain credibility. A serious speculative attack may also force the abandonment of a pegged regime or a sharp depreciation in a free floating regime.

[6] For detail of the theoretical literature, see Bastourre and Carrera (2004).

Reflecting the theoretical debate, the extensive empirical literature does not seem to come to any conclusion about the link between exchange rate regimes and macroeconomic volatility. The earlier empirical studies, however, support the "regime neutrality" view, indicating that there is no substantial relationship between exchange rate regimes and volatility of the macroeconomic variables. Baxter and Stockman (1989) initiated the empirical relation between a number of real macroeconomic variables, industrial production, consumption, government consumption, exports, real exchange rate and exchange rate regimes. By using descriptive statistics and F-test for the quarterly dataset of 23 OECD and 21 non-OECD countries over the period 1960-1985, they found evidence on regime neutrality with the exception of the real exchange rate volatility. Moreover, the volatility of exports, imports and the real exchange rate was generally higher during the recent float. Similarly, Flood and Rose (1995) investigated the time series behavior of monthly nominal bilateral exchange rates (against US$) and macroeconomic fundamentals, industrial production, M1, consumer price index, 3-month treasury bill returns, in OECD countries over the period 1960-1991. They found that only the volatility of virtual fundamentals (nominal exchange rate and interest rate) was significantly higher during the post-Bretton Woods, whereas the volatility of traditional fundamentals was unchanged across exchange rate regimes.

Dedola and Leduc (1999), using descriptive statistics and impulse-response functions and data from G-7 countries, found that the volatility of inflation, output, consumption, investment and labor did not appear to be significantly different across exchange rate regimes. However, the volatility of real and nominal exchange rates was higher after the collapse of Bretton Woods of fixed exchange rates. Singh (2002) employed GARCH model and quarterly weighted and unweighted real exchange rates for the period 1975:02-1996:03 and 1960: 01-1996:03, respectively. He added evidence on regime neutrality in the context of India. By using nonparametric tests and quarterly data of the nominal exchange rates of 17 European Monetary System (EMS) countries, Sopraseuth (2003) found that EMS caused a significant reduction in the volatility of real and nominal exchange rates (against DM) with the exception of Italy. But, the volatility of nominal exchange rates (against US$) in all countries, except Finland and Sweden, was not significantly different across exchange rate regimes. Moreover, the volatility of GDP, consumption, investment, net exports to GDP in these countries did not systematically depend on exchange rate regimes.

Some of the other studies in the empirical literature argue the non-neutrality of regimes. By using Stable Paretian Distributions and Chi-squared test and weekly data for five developed countries, Westerfield (1977) found that the variability of floating spot and forward exchange rates are higher than fixed rates during the period of January 4, 1962-July 24, 1975. Mussa (1986) employed descriptive statistics and concluded that over the period 1957-1984, the short-term variability of bilateral real exchange rates (against US$) for 15 industrial countries was on average 14 times higher under floating exchange rate regime than fixed. Conversely, Basu and Taylor (1999) investigated the co-movements and conclude that the volatility of consumption, current account, output and investment in 15 countries was relatively low after the collapse of Bretton Woods. Rose (1994) utilized the flexible-price model and single-factor exchange rate model and concludes that the quarterly data of virtual fundamentals (the bilateral exchange rates against DM and interest rates) for 8 industrial countries were more volatile after the Bretton Woods. Ghosh et al. (1997) used regression analysis and annual data for 136 countries over the period 1960-1990. They argued that pegged regimes appear with substantially lower volatility of inflation and higher volatility of output growth and employment.

Kent and Naja (1998) used non-parametric tests and monthly data for 90 countries over the period 1978-1994. They found that the short-term volatility of bilateral and effective real exchange rates was 12 and 3 times greater during the post-Bretton Woods period, respectively. However, the short-term volatility of effective real exchange rates among 27 countries, with stable inflation and growth rates, was only 2 times greater under floating regime. By using unit root testing and GARCH model and two different dataset, annual data from 1880 to 1997 and monthly data from 1957 to 1997, Liang (1998) found that the volatility of real exchange rates was higher after the Bretton Woods. Monacelli (1999), by using descriptive statistics and impulse-response functions for the quarterly data of the DM/US$ real and nominal exchange rates over the period 1960-1997, concluded that the volatility of real exchange rate was on average 4 times higher during the floating regime.

Kwan and Lui (1999) used the structural vector autoregressive model and quarterly data for the period 1973-1997. They found that nearly 70% of the reduction in the volatility of real per capita GDP and GDP deflator might be explained by the currency board in Hong Kong. They also concluded that demand shocks led higher short-term volatility in real per capita GDP during the adoption of

currency board. Similarly, Ran (2002) argued that out of 19 real and nominal variables, 12 exhibited more volatility under floating regime in Hong Kong, by using two-tailed F-test. Carrera and Vuletin (2002) used GMM methodology for dynamic panel data approach and data from 93 countries, 21 OECD and 72 non-OECD countries, over the period 1980-1999. They found a positive relationship between the flexibility of exchange rate regimes and the real exchange rate volatility and also argued that fix and intermediate regimes caused higher volatility under de jure classification. Finally, by using a dynamic panel data approach and data from two sample groups, 45 and 153 countries, Bastourre and Carrera (2004) argued that output volatility was lower during the recent floating period. De jure fixed regimes had greater volatility than de facto fixed regimes, whereas de jure and de facto flexible regimes showed similar volatility behavior.

3. Exchange Rate Management and Major Policy Changes in the Turkish Economy: 1980-2006

In this section, we provide a broad overview of the exchange rate regimes in the context of macroeconomic and structural policy framework in the Turkish economy for the 1980-2006 period. In line with the aim of this paper, we mainly focus on the exchange rate regime management.

January 1980-May 1981: Crawling Band

On January 24, 1980 a structural adjustment and stabilization programme was launched designed to encourage an export-oriented and liberalized economy. The priority of the program was disinflation, fiscal discipline and sustainable growth. Hence, the policy action taken by government included tight monetary and fiscal policy, external debt management policies, incentives to promote export and reforms to improve the efficiency of public enterprises and to encourage private capital formation. Moreover, this programme aimed to achieve liberalization in exchange and payment systems. The main objective was to make the Turkish Lira (TL) convertible. Since this period is associated with the balance of payments crisis and triple digit inflation, exchange rate regime changed fundemantally.[7] A realistic and flexible exchange rate regime was implemented to offset inflation differentials and to make Turkish exports more competitive. After a steep devaluation, 33%, in January 1980 frequent devaluations followed until May 1981. Gradual depreciation of TL was one of the essentials to promote export-led growth strategy. Over the

[7] The rate of inflation was 110% in 1980.

period 1980-1988, the real exchange rate annually depreciated by 6% on average (Aşıkoglu and Uçtum, 1995; Civcir, 1996; Keyder, 2002).

May 1981-December1999: Managed Float

From May 1981 onward, the Central Bank of the Republic of Turkey (CBRT) announced daily quotations to nominal exchange rate and TL depreciated continuously along with the inflation expectations. In August 1988, the central bank launched a new system to manage daily sessions for the interbank spot exchange market in which banks, financial institutions and licensed foreign exchange dealers were to join. On August 11, 1989, the decree No.32, the Protection of the Value of the Turkish Currency, issued which was associated with the convertibility of TL. By 1990, banks were allowed to determine exchange rates in their operations. Eventually, high capital inflows, supported with high real interest rates, and the implicit usage of exchange rate as an anti-inflationary policy tool caused slowing down the continuous depreciation (Aşıkoğlu and Uçtum, 1995; Keyder, 2002). During early 1990s, public sector borrowing requirement was accelerating and short-term domestic borrowing was used to finance the fiscal deficits. Beside a significant real appreciation of TL for two consecutive years, that causes external deficit, unsustainable fiscal balances, debt-rollover problem and monetization, increased the devaluation expectations by the end of 1993.[8] Eventually, structural imbalances were followed by a total devaluation of 173% in nominal terms between January 1994 and April 1994 (Berument and Dinçer, 2004).

The financial crisis of 1994 slowed down with short-term monetary measures, very high interest rates and excessive reserve losses, and eventually, the new stabilization program in April 5, 1994. Strengthening of the privatization process was the major structural change aimed by the program. In the aftermath of the crisis, loosening of the monetary policy and fiscal austerity caused increase in export/import ratio and high rates of growth. Foreign reserve accumulation also realized. Post-crisis years, however, are characterized with depreciation of TL in nominal terms, high rates of inflation, increase in budget deficit and the global financial crises (the Asian and Russian crises) leading difficulty in foreign borrowing. Moreover, after the second half of 1997, a new system was also introduced which would not allow the budget deficits to be financed by the central

[8] The early years of the 1980 stabilization program is characterized by steep devaluations, monetized fiscal deficits and financial liberalization. However, the inconsistency between fiscal policy and exchange rate policy started to be obvious in early 1990s (Aşıkoğlu and Uçtum, 1995).

bank. On the other hand, to stabilize the real exchange rate, the CBRT continued to depreciate the exchange rate in line with short-term inflation expectations, external imbalances and budget deficit until another stabilization programme in December 1999 (Keyder, 2002; Berument and Dinçer, 2004).

December 1999-February2001: Crawling Peg

The Exchange Rate Based Stabilization Programme, or 2000 Disinflation Programme was embarked in December 1999 and focused on reducing the inflation rate to single digits at the end of 2002. This programme was fundamentally relied on fiscal austerity, nominally anchored exchange rate basket, structural reforms, privatization and income policy.[9] Monetary policy has no active role since TL would be issued only against the purchase of foreign exchange. The performance criteria of the monetary control were Net Domestic Assets and Net International Reserves shaped with a ceiling and floor, respectively (Keyder, 2002). Therefore, the source of liquidity generating mechanism was the short-term capital inflows which was the main weakness of the programme.

Since the exchange rate policy was focused on forward-indexed inflation targets, the CBRT declared an exchange rate basket, 1 US$+0.77 €, which was based on announcements of daily depreciation rate for one-year period. By the end of 2000, the percentage change in TL value of the basket would be fixed at 20%, the wholesale price index inflation target. For the whole period, the exchange rate policy would consist of two different regimes. For the following first 18-months (January 2000-June 2001), the revaluation rate of the basket would be 20%, called as pre-announced crawling peg regime without a band. In the second 18-months, the band would be widening gradually and pre-announced crawling peg regime with a band would contribute to the smooth transition to free float.[10] In this context, the pre-announced exchange rate was essential for the reduction of inflation expectations and the nominal interest rate, parallel to the decline in public sector borrowing requirement (Keyder, 2002).[11]

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[9] The structural measures fundamentally cover the banking sector reform, public sector budget, subsidization and income support to the agricultural sector, social security reform, accelerated privatization, domestic debt management, budgetary funds and tax reform.

[10] The width of the band was 7.5% for the period July 2001-December 2001, 15% between January 2002-June 2002 and finally, 22.5% for the period July 2002-December 2002.

[11] Conversely, over the 1990-1999 period, exchange rate policy was implemented parallel to the inflation expectations.

After the adoption of the programme, significant improvement in inflation expectations lead to a fall in interest rates on Treasury bills, high capital inflows were realized, primary surplus was above targeted levels, public sector debt/GDP ratio declined and output growth was also realized. However, there were several factors make the financial system highly fragile, particularly an overvalued TL and current account deficit (5% in GDP), a high short-term external debt/reserves ratio (192%), capital inadequacy in financial sector, short positions in the banking sector (around $18 billion), duty loses of the state banks, bank balance-sheet weaknesses, including maturity and currency mismatches and dollarization.[12] In November 2000, runs on small-size banks triggered the banking crisis and sudden reversal of capital inflows, thereby causing rapid depletion of foreign reserves. On February 19, 2001 political difficulties led to a more serious attack against TL. CBRT forced to sell approximately one-third of reserves, $7.5 billion, in one day and overnight interest rates skyrocketed to 2000% and 4000% on February 20 and 21, respectively. The devaluation rate reached to 40% in one week. Finally, the CBRT decided to float the TL on February 22 and depreciation continued until October 2001 (Selçuk, 2005).

February 2001- : Free Float

On May 15, 2001 a new programme, The Programme for Strengthening the Turkish Economy, was initiated which relies on mainly three pillars: 1) fiscal austerity, a strong primary surplus, 2) free floating regime and 3) structural reforms, particularly restructuring of the deeply troubled banking sector, massive fiscal adjustment, public debt management and privatization.[13]

Under the new exchange rate regime, Base Money functioned as a nominal anchor rather that the exchange rate anchor which was implemented only 14 months. Since the exchange rate stabilization is essential for the price stabilization, interventions to the foreign exchange market designed to prevent extreme volatility and to accumulate foreign reserves. In the context of financial stability and floating exchange rate regime, monetary policy expected to play a more active role. Hence, an amendment to the central bank law has been approved to give full operational independence as a key step in adopting an official inflation targeting regime.

[12] In the pre-crisis period, dollarization was 52% of total deposits.
[13] The fiscal cost of banking crisis was 24% of GDP.

4. Data

The data set consists of monthly values of the real exchange rate, inflation, output growth, foreign exchange reserves, volume of export and import and stock market index.[14] The data were taken from International Financial Statistics (IFS) and the electronic data delivery system of the Central Bank of the Republic of Turkey (CBRT). Table 2 reports the summary statistics of the variables used in the study.

Table 2
The Data Descriptions of the Macroeconomic Variables

Variables	Period	Mean	Standard Deviation
reer	1980:1-2006:3	119.60	19.90
inf	1980:1-2006:2	0.03	0.02
ip	1985:1-2006:1	84.51	21.02
res	1981:1-2006:2	12354.70	12286.72
exp	1980:1-2006:2	1796.87	1491.98
imp	1980:1-2006:2	2847.18	2360.43
ise	1986:1-2006:4	6118.43	9486.12

Note: reer, inf, ip, res, exp, imp and ise represent CPI-based real effective exchange rate index, consumer price index, industrial production index, Central Bank's gross foreign exchange reserves, volume of export, volume of import and the closing price index of Istanbul Stock Exchange, National-100 (January, 1986=1), respectively.

Many macroeconomic time series contain unit roots dominated by stochastic trends. Unit roots are important in examining the stationarity of a time series because a non-stationary regressor invalidates many standard empirical results. The presence of a stochastic trend is determined by testing the presence of unit roots in time series data. In this study, Augmented Dickey–Fuller (ADF) tests have been used to test for unit root. Logarithmic differences are taken of the macroeconomic variables. Table 3 reports the unit root test results for the level and the first difference of the variables. Table 3 presents results for the seven time series. The results indicate that we cannot reject stationarity for the first differences of the variables. Thus, all time series are I(1).

[14] The variables selected do not exhaust all the macroeconomic variables. Those selected, however, have been chosen in most of the studies in the literature and considered as the most important macroeconomic variables that have been affected from the exchange rate regimes. We include real exchange rate in our study because the significant shifts in the nominal exchange rate are associated with the changes in exchange rate regimes. Real exchange rate explicitly includes this change and is the most important variable used in almost all related studies. We consider the rate of inflation and industrial production, since the variability of nominal exchange rate directly affects them, in particularly developing countries. Foreign exchange reserves are also closely related with the exchange rates shifts. Similarly, the trade variables can easily affected from the exchange rate variability.

Table 3
Unit Root Test: ADF

	Level		First Difference	
	Trend	**No Trend**	**Trend**	**No Trend**
lreer	-2.267 (3)	-2.419 (2)	-9.032 (4)	-8.893 (4)
linf	-2.007 (12)	-1.973 (12)	-7.867 (11)	-7.854 (11)
lip	-2.699 (12)	-1.022 (12)	-4.891 (12)	-4.881 (12)
lres	-3.155 (1)	-0.112 (0)	-16.451 (0)	-16.464 (0)
lexp	-2.559 (12)	-0.530 (12)	-5.115 (12)	-5.123 (12)
limp	-3.306 (12)	0.305 (12)	-6.160 (11)	-5.213 (12)
lise	-2.471 (3)	-1.384 (3)	-7.703 (2)	-7.648 (2)

Note: lreer, lip, lres, lexp, limp and lise represent natural logarithm of reel exchange rate, industrial production index, foreign exchange reserves, volume of export and import and stock market index, respectively. Numbers in parenthesis are optimum number of lags determined according to AIC and critical values are based on (MacKinnon, 1991); critical values are -3.50 (99%) and -4.056 (99%) with no trend and with trend, respectively.

5. Conditional Volatility Models and Estimation

Model

The time-varying volatility is conventionally estimated by Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models which are the generalized version of ARCH model. Engle (1982) introduced the ARCH model to capture the time-varying risk, which allows us to estimate the time-varying conditional variance. ARCH (p) process is denoted as:

$$h_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 \qquad (1)$$

where ε_t represents the disturbance terms that are normally distributed. GARCH model is the extension of ARCH models by including lagged values of the conditional variance. Bollerslev (1986) specified conditional variance and denoted as GARCH (p,q) process as:

$$h_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j} \qquad (2)$$

The GARCH specification requires that $\sum_{i=1}^{p} \alpha_i + \sum_{j=1}^{q} \beta_j$ be less than one to satisfy the stationary condition and α_0 , α_i , β_j be positive for non-negativity condition. These models employ volatility clustering which helps to provide the magnitude but not the sign of the random shocks.

In this study, the monthly conditional volatility of the macroeconomic variables is estimated using the following GARCH model:

$$h_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j} + CR_{t-1} \quad (3)$$

where CR is dummy for crises of 1994 and 2001.[15] Since the Turkish economy experienced two major financial crises in recent years, we take the effects of crises on the macroeconomic variables in order to accurately estimate the volatility series.

Estimation Results

Since several empirical studies indicate that GARCH (1,1) model adequately fits many economic time series, initially such models were estimated for all series. If the likelihood-ratio test indicated a better fit for a GARCH (p, q) model with a higher p, new models with higher p values were estimated until no significant improvement in the fit could be detected. Finally, from the estimated variance equation of the GARCH model, conditional volatility forecasts could be obtained. These forecasts, transformed into standard deviation form, will be used as our conditional GARCH volatilities in the analysis further on.

After testing the null of no GARCH effect in the standardized errors, GARCH(1,1) process is estimated only for real exchange rate, inflation, reserves and import series. Table 4 presents the results of the modelling of macroeconomic volatility. The GARCH parameter, β_1, is significantly greater than the ARCH parameter, α_1, (a strong GARCH effect) in the volatility models of real exchange rate, inflation and reserves, implying that these volatilities are influenced by random shocks for long-periods. In other words, the effects of random shocks on real exchange rate, inflation and reserve volatility are more persistent. Moreover, the ARCH and GARCH parameters are between zero and one indicating positive variance and sum of the parameters fairly close to unity for inflation and reserves. There appears to be no significant distinction between the effects of short and long-period shocks on import. We could only find ARCH effect for industrial production, export and stock market index showing that these volatility series are affected by only short-period random shocks.

[15] Crises periods for 1994 and 2001 are defined as 1994:M1-1994:M07 and 2000:M11-2001:M05, respectively.

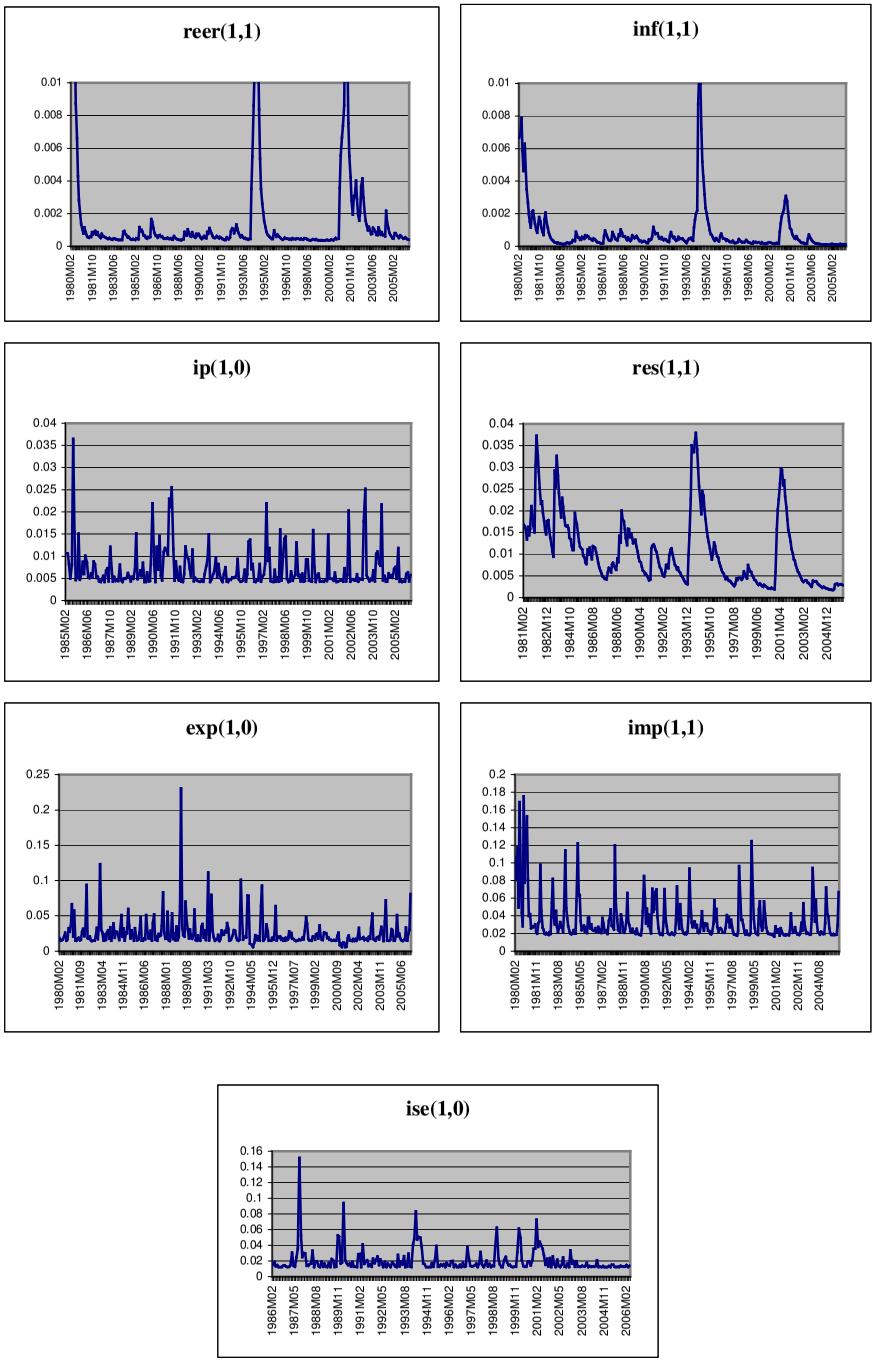
Table 4
Estimated Volatility Models

	α_0	α_1	β_1	$(\alpha_1 + \beta_1)$	Log-L	AIC
reer	0.0001 (0.000)	0.162 (0.002)	0.624 (0.000)	0.786	671.770	-4.246
inf	0.000 (0.018)	0.220 (0.000)	0.717 (0.000)	0.937	764.525	-4.853
ip	0.004 (0.000)	0.424 (0.001)	-	0.424	280.959	-2.198
res	0.000 (0.097)	0.119 (0.000)	0.853 (0.000)	0.972	298.565	-1.950
exp	0.014 (0.000)	0.478 (0.000)	-	0.478	153.648	-0.956
imp	0.012 (0.000)	0.351 (0.000)	0.316 (0.000)	0.667	106.061	-0.645
ise	0.012 (0.000)	0.327 (0.000)	-	0.327	145.102	-1.161

Note: reer, ip, res, exp, imp and ise represent the real exchange rate, industrial production index, foreign exchange reserves, volume of export and import, stock market index, respectively. Numbers in parenthesis denote p-values of the related coefficients.

The estimated volatility patterns for all fundamental variables are plotted in Figure 1. As expectedly, there have been distinct periods of high volatility in most of the macroeconomic variables corresponding to financial crises of 1994 and 2001. The volatility of almost all variables is high during the crawling band regime of early 1980s. While there seems to be lower volatility of real exchange rate and inflation during the long period of managed float regime. The adoption of crawling peg regime in December 1999 leads to a higher volatility in import and stock market index and lower volatility in export. Moving from crawling peg to floating regime after the financial crisis of February 2001, however, causes a significant increase in the volatility of real exchange rate, inflation, foreign exchange reserves and stock market index at a decreasing rate. Moreover, the volatility of industrial production, export and import appears to be similar across alternative exchange rate regimes.

Fig. 1. Shifts in Conditional Variance



Some summary statistics of estimated volatility models in the context of "de jure" and "de facto" classifications are presented in Table 5 and 6. Most of the series exhibit excess kurtosis and skewed behavior which are the signs of leptokurtotic distributions.[16] Our results indicate that the real exchange rate, inflation, export and stock market index present excess kurtosis, under managed float. Surprisingly, the highest mean variances exist in crawling band and crawling peg regimes under "de jure" and "de facto" classifications, respectively.

Table 5
Descriptive Statistics of Estimated Volatility Models: "De Jure" Classification

Crawling Band (1980:1-1981:4)							
	Reer(1,1)	Inf(1,1)	Ip(1,0)	Res(1,1)	Exp(1,0)	Imp(1,1)	Ise(1,0)
Mean	80.159	39.877	n.a.	162.522	267.861	917.116	n.a.
Std.dev	99.177	22.845	n.a.	6.541	158.965	484.145	n.a.
Skew.	1.393	0.348	n.a.	-0.784	1.710	0.460	n.a.
Kurt.	0.768	-1.464	n.a.	n.a.	2.218	-0.978	n.a.

Managed Float (1981:5-1999:11)							
	Reer(1,1)	Inf(1,1)	Ip(1,0)	Res(1,1)	Exp(1,0)	Imp(1,1)	Ise(1,0)
Mean	9.991	7.229	73.532	117.136	272.932	329.099	207.617
Std.dev.	20.947	12.883	45.126	77.994	225.553	192.562	161.024
Skew.	6.039	5.659	2.893	1.332	4.636	2.577	4.589
Kurt.	39.712	35.448	11.756	1.511	32.018	7.576	29.069

Crawling Peg (1999:12-2001:2)							
	Reer(1,1)	Inf(1,1)	Ip(1,0)	Res(1,1)	Exp(1,0)	Imp(1,1)	Ise(1,0)
Mean	18.548	5.484	62.881	59.912	153.741	252.994	305.955
Std.dev.	25.721	6.656	38.249	72.117	49.866	108.430	185.393
Skew.	1.461	1.585	2.160	1.734	0.154	2.205	1.113
Kurt.	0.496	1.073	3.551	1.492	0.727	4.778	0.479

Free Float (2001:2-)							
	Reer(1,1)	Inf(1,1)	Ip(1,0)	Res(1,1)	Exp(1,0)	Imp(1,1)	Ise(1,0)
Mean	23.387	5.034	65.433	74.279	221.029	277.787	167.879
Std.dev.	32.018	7.329	43.395	79.836	135.131	154.978	74.399
Skew.	2.741	2.334	2.989	1.700	2.651	2.477	2.254
Kurt.	7.667	4.599	8.794	1.611	8.117	6.343	4.581

Note: Reer(1,1), Inf(1,1), Ip(1,0), Res(1,1), Exp(1,0), Imp(1,1) and Ise(1,0) implies the calculated GARCH(p,q) specification for each variable.

[16] Normal distribution has skewness of zero and kurtosis of three.

Table 6
Descriptive Statistics of Estimated Volatility Models: "De Facto" Classification

Crawling Peg (1980:1-1981:3)							
	Reer(1,1)	Inf(1,1)	Ip(1,0)	Res(1,1)	Exp(1,0)	Imp(1,1)	Ise(1,0)
Mean	85.389	41.481	n.a	166.047	276.479	952.556	n.a
Std.dev.	100.751	22.814	n.a	3.318	161.288	481.807	n.a
Skew.	1.299	0.219	n.a	n.a	1.633	0.348	n.a
Kurt.	0.476	-1.506	n.a	n.a	1.909	-1.001	n.a

Managed Float (1981:4-1998:1)							
	Reer(1,1)	Inf(1,1)	Ip(1,0)	Res(1,1)	Exp(1,0)	Imp(1,1)	Ise(1,0)
Mean	10.623	7.825	73.563	125.165	277.010	323.529	210.483
Std.dev.	21.917	13.442	46.120	77.942	235.073	180.331	167.009
Skew.	5.743	5.381	3.012	1.259	4.476	2.636	4.593
Kurt.	35.779	31.934	12.327	1.317	29.544	8.240	28.526

Crawling Peg around DM (1998:2-1998:12)							
	Reer(1,1)	Inf(1,1)	Ip(1,0)	Res(1,1)	Exp(1,0)	Imp(1,1)	Ise(1,0)
Mean	4.286	2.487	80.727	54.662	231.979	342.454	223.094
Std.dev.	0.439	0.611	46.435	10.751	109.538	239.698	153.357
Skew.	0.631	0.756	0.878	0.611	1.552	2.104	2.199
Kurt.	-0.864	1.028	-1.100	-0.449	1.545	4.468	4.725

Crawling Peg around € (1999:1-2001:1)							
	Reer(1,1)	Inf(1,1)	Ip(1,0)	Res(1,1)	Exp(1,0)	Imp(1,1)	Ise(1,0)
Mean	9.858	3.324	64.755	42.599	187.527	330.837	236.330
Std.dev.	16.742	4.134	34.321	43.262	65.697	237.982	161.496
Skew.	2.807	2.929	1.858	3.117	0.553	2.705	1.922
Kurt.	6.944	7.989	2.524	9.477	1.097	8.693	3.240

Free Float (2001:2-)							
	Reer(1,1)	Inf(1,1)	Ip(1,0)	Res(1,1)	Exp(1,0)	Imp(1,1)	Ise(1,0)
Mean	23.387	5.034	65.433	74.279	221.029	277.787	167.879
Std.dev.	32.018	7.329	43.395	79.836	135.131	154.978	74.399
Skew.	2.741	2.334	2.989	1.700	2.651	2.477	2.254
Kurt.	7.667	4.599	8.794	1.611	8.117	6.343	4.581

Note: Reer(1,1), Inf(1,1), Ip(1,0), Res(1,1), Exp(1,0), Imp(1,1) and Ise(1,0) implies the calculated GARCH(p,q) specification for each variable.

6. The Relationships Between Macroeconomic Volatility and Exchange Rate Regimes

To examine whether the impact of exchange rate regimes on the volatility of macroeconomic variables is similar in both "de jure" and "de facto" classifications, we use t-test. A t-test is a statistical tool used to determine whether a significant difference exists between the means of two series.

The hypothesis is:

$$H_0 : \mu_{reg1} - \mu_{reg2} = 0$$

$$H_1 : \mu_{reg1} - \mu_{reg2} > 0$$

If the null hypothesis cannot be rejected, it implies that the variations in the mean of fundamental variables are the same under alternative exchange rate regimes. Therefore, the linked exchange rate regimes are not statistically different from each other.

Table 7 and 8 summarize the results of the t-tests. Under "de jure" classification, the variations in the mean of real exchange rate volatility across two regimes are the same, particularly in the crawling band regime. Similarly, out of six pairs of regimes, only two of them indicate that the change in mean of volatility of inflation and foreign exchange reserves across two regimes is not statistically different from each other. Hence, the volatility of inflation and foreign exchange reserves displays different behavior across different regimes. The volatility of the industrial production, however, seems to be insensitive to regime changes, since the means of two regimes are the same in any pair. The variations in the mean of the import volatility across two regimes are different from each other in almost all cases while for the export volatility, the findings indicate different means only for the three cases. The means of the stock market index volatility between two regimes are same only one case, indicating that the stock market volatility is more sensitive to exchange rate regime changes.

Under "de facto" classification, the variations in the mean of the volatility of real exchange rate, inflation and industrial production, export and stock market indices are almost the same across two regimes. These findings indicate the insensitiveness of the volatility of key macroeconomic variables toward different regimes. The mean of the volatility of foreign exchange reserves and import, however, show different behavior across regimes. Overall, the volatility of inflation, import, foreign exchange reserves and stock market index are sensitive to de jure regime changes. However, the volatility of import and foreign exchange reserves are weakly sensitive to de facto regime changes. Therefore, "de facto" regimes are more neutral concerning its impacts on the volatility of macroeconomic variables than "de jure" regimes.

Table 7
The Variations in the Mean of Variables across Exchange Rate Regimes: "De Jure"

	Reer		Inf		Ip		Res		Exp		Imp		Ise	
	t-sta.	t-cri.	t-sta.	t-cri.	t-sta.	t-cri.	t-sta.	t-cri.	t-sta.	t-cri.	t-sta.	t-cri.	t-sta.	t-cri.
CB&MF	2.736	1.761	5.476	1.753	n.a.	n.a.	1.005*	1.651	-0.115*	1.734	4.679	1.761	n.a.	n.a.
CB&CP	2.328	1.745	5.597	1.745	n.a.	n.a.	2.403	1.745	2.652	1.739	5.184	1.753	n.a.	n.a.
CB&FF	2.189	1.753	5.880	1.753	n.a.	n.a.	1.999	1.670	1.114*	1.665	5.040	1.753	n.a.	n.a.
MF&CP	-1.260*	1.753	0.907*	1.717	0.887*	1.652	2.762	1.651	6.005	1.666	2.469	1.720	-1.987*	1.745
MF&FF	-3.924*	1.650	1.950	1.653	1.162*	1.651	4.000	1.661	2.172	1.654	2.100	1.658	2.819	1.651
CP&FF	-0.516*	1.705	0.365*	1.713	-0.248*	1.710	-0.559*	1.713	-1.928*	1.665	-0.749*	1.697	2.907	1.753

Note: CB, MF, FF and CP denote crawling band, managed float, free float and crawling peg, respectively.
*, shows that the null hypothesis cannot be rejected at 5%. The first column for each variable reports the t-statistics while second column reports the critical values.

Table 8
The Variations in the Mean of Variables across Exchange Rate Regimes: "De Facto"

	Reer		Inf		Ip		Res		Exp		Imp		Ise	
	t-sta.	t-cri.	t-sta.	t-cri.	t-sta.	t-cri.	t-sta.	t-cri.	t-sta.	t-cri.	t-sta.	t-cri.	t-sta.	t-cri.
MF&CPM	4.094	1.652	5.538	1.652	-0.494*	1.795	11.067	1.659	1.219*	1.745	-0.257*	1.795	-0.242*	1.654
MF&CP€	0.168*	1.651	3.582	1.659	1.130*	1.684	8.060	1.678	4.236	1.657	-0.184*	1.651	-0.717*	1.654
MF&FF	-3.567*	1.650	2.094	1.653	-1.179*	1.652	4.386	1.660	2.338	1.653	1.790	1.650	2.539	1.652
CPM&CP€	-1.094*	1.690	-0.662*	1.690	1.153*	1.690	0.905*	1.690	1.250*	1.770	0.134*	1.690	-0.234*	1.724
CPM&FF	-1.967*	1.666	-1.145*	1.666	1.063*	1.667	-0.808*	1.666	0.293*	1.745	0.862*	1.782	1.170*	1.795
CP€&FF	-2.000*	1.662	-1.095*	1.663	-0.076*	1.672	-1.870*	1.663	-1.180*	1.663	1.028*	1.692	2.035	1.701
CP&MF	-2.772*	1.770	-5.454*	1.761	n.a.	n.a.	0.739*	1.652	-0.011*	1.739	4.861	1.770	n.a.	n.a.
CP&CPM	-3.011*	1.770	-6.392*	1.770	n.a.	n.a.	27.834	1.943	0.782*	1.713	4.131	1.724	n.a.	n.a.
CP&CP€	-2.783*	1.770	-6.201*	1.770	n.a.	n.a.	3.962	1.708	1.973	1.753	4.528	1.739	n.a.	n.a.
CP&FF	-2.276*	1.761	-5.907*	1.761	n.a.	n.a.	1.612*	1.670	1.335*	1.665	5.179	1.761	n.a.	n.a.

Note: MF, CPM, CP€, FF and CP denote managed float, crawling peg around DM, crawling peg around €, free float and crawling peg, respectively.
*, shows that the null hypothesis cannot be rejected at 5%. The first column for each variable reports the t-statistics while second column reports the critical values.

7. Conclusion

The objective of this paper is to examine the impact of exchange rate regimes on the volatility of fundamental variables in the context of "de jure" and "de facto" classifications for the period 1980-2006 in Turkey. In this respect, the empirical results suggest that there is a persistency of shocks in real exchange rate, inflation and foreign exchange reserve series, a strong GARCH effect. Even though managed float regime indicates the highest risk for most of the macroeconomic series in both "de jure" and "de facto" classifications, there is a little evidence on the statistically significant difference between the exchange rate regimes, particularly under "de facto" classification**.** As the variation in the mean of the most of the variables is not sensitive to exchange rate regime changes, macroeconomic variables exhibit similar volatilities across alternative exchange rate regimes. Overall, "de facto" regime neutrality is stronger than "de jure" regime neutrality. With respect to regime neutrality, our findings are similar to the findings of Baxter and Stockman (1989), Flood and Rose (1995) and Singh (2002).

The monetary authority adopts exchange rate policy to pursue the macroeconomic stability, to break the inflation inertia, to gain credibility or to cope with serious speculative attacks. The findings of this study indicate that regime commitment may be more effective on the volatility of inflation, import, foreign exchange reserves and stock market index, since these are more sensitive to de jure regime changes. However, the volatility of import and foreign exchange reserves are strongly influenced by the actual or "de facto" regime changes. Since volatility of imports and foreign exchange reserves show sensitivity in both "de jure" and "de facto" regime changes, the monetary authority needs to advocate a particular exchange rate regime to affect these two macroeconomic variables.

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